

FISH PASSAGE GUIDELINES WHEN INSTALLING STREAM CROSSINGS



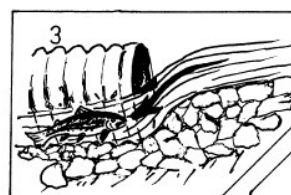
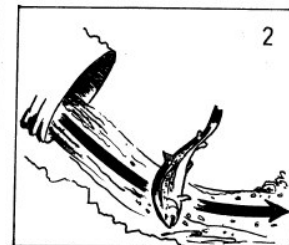
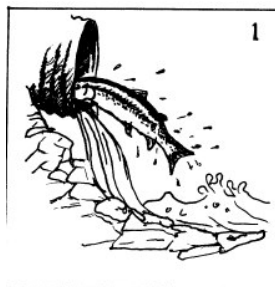
State Forester Forum

Under the Idaho Forest Practices Act and the Stream Channel Protection Act, all stream crossings on fish bearing streams must provide for fish passage. Unfortunately, few guidelines exist that describe how stream crossings should be installed so they do not inhibit fish passage. As a result, numerous crossings have been built that either block or delay fish passage. This Forester Forum provides guidelines that will help individuals design and install stream crossings that will not impede or delay fish passage. These guidelines were developed in cooperation with the Idaho Departments of Fish and Game and Water Resources.

Minimum Requirements by Law

The requirement and direction to provide fish passage at forest road crossings can be found in state of Idaho law. The Idaho Forest Practices Act, Title 38, Chapter 13, Idaho Code, pertaining to road construction, reconstruction and maintenance (Rule 040) states: "Culvert installations on fish bearing streams must provide for fish passage". More specific guidelines can be found in the rules pertaining to Stream Channel Alteration, Title 37, Chapter 03, Idaho Code. These rules state that in streams where fish passage is of concern, the following criteria must be met to ensure that passage will not be inhibited by a proposed crossing:

1. Minimum water depth at crossing will be at least 8 inches for salmon and steelhead, and at least 3 inches in all other cases.
2. [Depending on the type of fish present, salmon/steelhead, resident fishes, or both] Water velocities shall not exceed those shown in the Alaskan Curve for more than a 48 hour period (see Figure 1).
3. Upstream drops at culvert entrance (inlet) will not be permitted,
4. And maximum outlet drop shall not exceed 1 foot.



The rules stated above spell out a design process that attempts to match the hydraulic performance of a culvert with a target fish species. Inconsistency occur when attempting to strictly apply the fish passage criteria required by the Stream Channel Alteration rule, therefore for the purposes of on-the-ground application, a target fish and design flow must be established. For the purpose of developing

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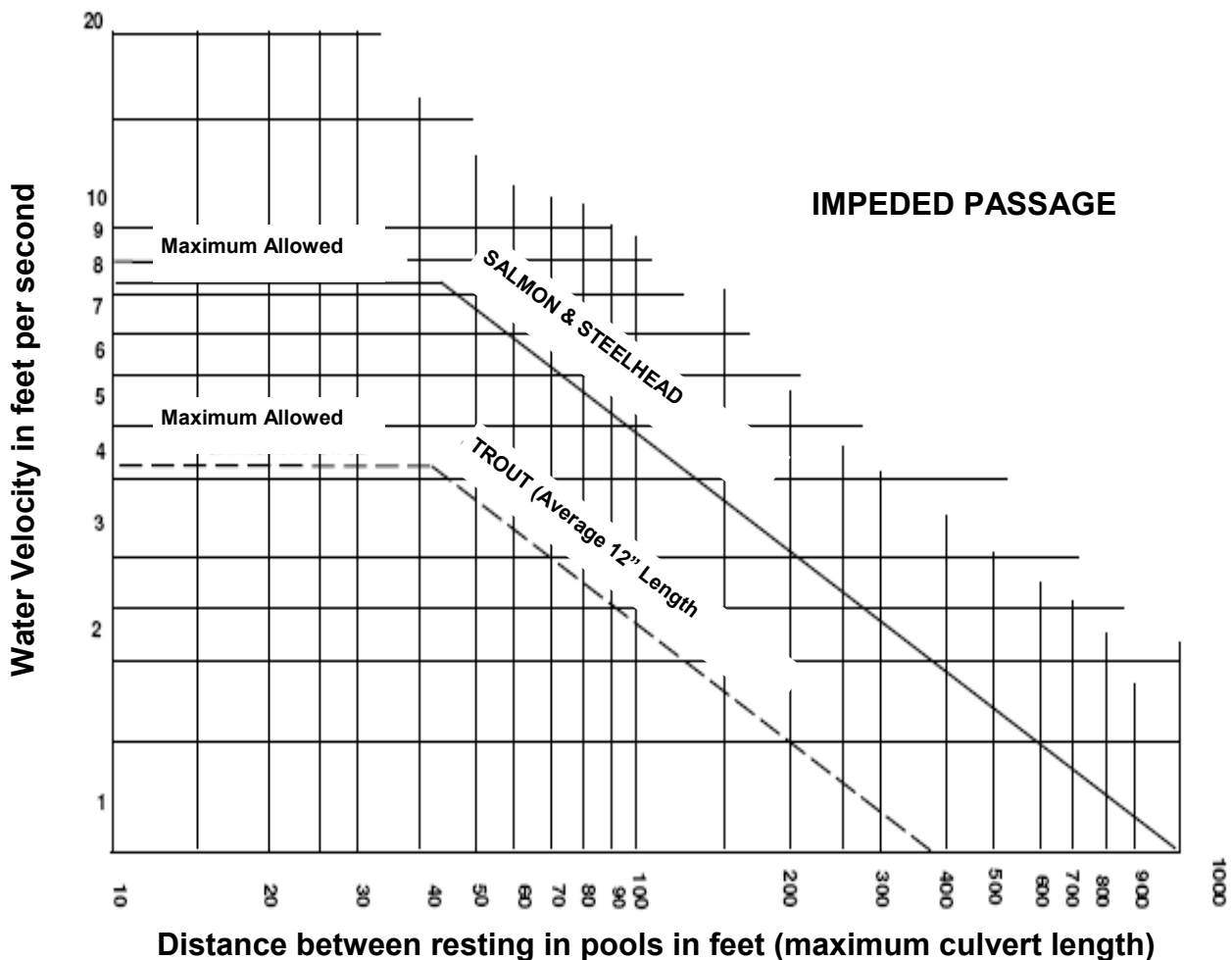
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this guidance, a 6 inch cutthroat trout was used as the target fish species requiring passage through a culvert during high flows that are exceeded 5% of the time during average flow years.

Hydraulic analysis of the velocity component of the Stream Channel Alteration rule using the stated target fish and design flow has led to the following specific guidelines (Chart 1, and Figure 2A) for installing traditional non-embedded culverts at stream grade. This guidance assumes the culvert is properly sized to handle a 50 year peak flow event as required by Idaho's Forest Practices Act. When using this chart, the difference between stream gradient and pipe gradient should be no more than 2%. Pipes that are installed at less than 0.5% will likely accrue substrate material and culvert size may need to be increased one diameter class to allow design peak flow.

FIGURE 1. Swimming capability of migrating salmon and trout (Alaskan Curve)



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Chart 1. This table shows the maximum allowable stream gradient at which a traditional non-embedded culvert can be installed that will meet Idaho's hydraulic design criteria for fish passage. This table assumes that the culvert is sized to pass a 50 year peak flow event.

| <i>Drainage Area (Acres)</i> | <i>Maximum Allowable Gradient of Installed Culvert</i> |
|------------------------------|--|
| <200 | 3% |
| 201-350 | 2% |
| 351-1000 | 1% |
| 1001-2600 | 0.5% |
| 2601-8200 | 0% |

From this analysis, one can see that the use of traditional non-embedded culverts on fish bearing streams is limited to relatively low gradient streams. Outlet drops should not be permitted unless an adequate resting/jumping pool is maintained below the culvert outlet. Ideal jumping conditions exist when the ratio of pool depth to jump height is 1.25:1.

The rest of this forum is dedicated to discussing and depicting alternative stream crossing methods and designs that will provide uninhibited fish passage at all stream grades. Based on use requirements, these stream crossing alternatives have been divided into permanent and temporary structures. After the various stream crossing alternatives are discussed, a section is included that provides a step-by-step guide to help the landowner choose an appropriate stream crossing.

Permanent Stream Crossing Structures

Permanent structures are placed at stream crossings where the transportation network requires years of continuous use. These types of crossings are usually installed on main haul routes, and major access roads. Careful consideration of alternative transportation and logging systems should be considered prior to installing new permanent stream crossings.

Permanent stream crossing structures that allow for fish passage include:

1. Fish Ladders
2. Structures such as buried (embedded) culverts, fords, and bottomless arches that simulate the natural stream bed
3. Bridges that span the stream to allow for long-term dynamic stream channel stability.

Embedded culverts, bottomless structures, or bridges simulating the natural stream channel allow all life stages and species of fish to pass during normal migration times and flow conditions, and are the preferred alternatives for installing permanent stream crossings for fish passage under certain conditions. Removable "fish ladders" can be installed in pre-existing culverts to provide fish passage; construction of new stream crossings that incorporate culverts with removable fish ladders should be avoided.

Table 1 (page 5) lists the different kinds of permanent stream crossing structures, and provides information that will help the landowner choose the appropriate structure for a given crossing. Figure 2 C-F depicts various embedded culvert and fish ladder design considerations.

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Temporary Stream Crossing Structures

Temporary stream crossings are installed across a stream or watercourse for short-term use (a period of less than one year) then removed. Unlike permanent stream crossings, temporary stream crossings are not necessarily required to pass fish as long as the structure is removed prior to important fish migration and spawning times. Specialized knowledge of the type of fish present and important migration and spawning times is required prior to installing a temporary stream crossing that is not designed for fish passage. Temporary stream crossings may consist of a ford, log crossing, culvert, existing crossing structure or bridge.

Table 2 (page 6) lists the different types of temporary stream crossings, and provides information that will help the landowner choose the appropriate structure for a given crossing.

Table 3 (below) lists the general spawning and migration times of salmonid species in Idaho. These spawn and migration times may be further refined by consulting a fish biologist with local knowledge.

Table 3. Timing of migration and spawning of salmonids in Idaho.

| <i>FISH SPECIES</i> | <i>TIMING OF SPAWNING MIGRATION</i> | <i>TIMING OF SPAWNING</i> |
|----------------------------|--|----------------------------------|
| Rainbow trout | Mid Fed.—Late June | Mid March—Late June |
| Cutthroat Trout | Early March—Early July | Late March—Early July |
| Chinook Salmon | Mid May—Late Sept. | Early August—Early Oct. |
| Bull Trout | Late May—Early Oct. | Mid August—Late Oct. |
| Brook Trout | Early July—Late Oct. | Early Sept.—Late Nov. |
| Brown Trout | Mid July—Early Jan. | Late Sept.—Early Dec. |
| Kokanee | Late July—Early Jan. | Early Sept.—Early Jan. |
| Lake Whitefish | Early Oct.—Late Jan. | Early Oct.—Late Jan. |
| Mt. Whitefish | Early Oct.—Mid Feb. | Mid Oct.—Early Feb. |

Table 1. Information on various **permanent** stream crossing alternatives that can help with design plans.

| Stream Crossing Alternatives | Maximum stream gradient allowing fish passage** | Technical Difficulty (low/ med/high) | Culvert Oversizing Needs | Potential of Plugging (low/ med/high) | Problems with minimum depths during low flow | Additional Comments |
|--|--|---------------------------------------|--|---------------------------------------|--|---|
| 1. Culvert installed at stream grade | ~0%, >2601 acres ~0.5%, 1001 - 2600 acs ~1.0%, 351 - 1000 acrs ~2.0%, 201 - 350 acres ~3.0%, < 200 acres | low | No need to oversize culvert | medium | Yes | Smooth or concrete culverts require flatter slopes than those listed. Round culverts maintain the deepest depths during low flows. If depths < 3" occur during low flow, consider another alternative. |
| 2. Culvert with fish ladder | 4.0% | medium | increase culvert size 1 diameter class | medium | No | The detachable fish ladder can be removed from a culvert if complications occur. Must be maintained and an adequate amount of seeding completed. |
| 3. Culvert with buried inlet and outlet | 5.0% | Medium/high | encompass bankfull width | medium | Usually Not | Backfill culvert with cobble and boulder substrates. Culvert width must encompass bankfull width for substrate to remain in pipe. May not work in streams dominated by boulder, bedrock, or all fine grained. |
| 4. Culvert with inlet buried more than outlet | 6.5% | Medium/high | encompass bankfull width | medium | Usually Not | Backfill culvert with cobble and boulder substrates. Culvert width must encompass bankfull width for substrate to remain in pipe. May not work in streams dominated by boulder, bedrock, or all fine grained. |
| 5. Culvert with baffles; Inlet and Outlet buried | 8.0% | high | encompass bankfull width | medium | No | Backfill culvert with cobble and boulder substrates. Culvert width must encompass bankfull width for substrate to remain in pipe. May not work in streams dominated by boulder, bedrock, or all fine grained. |
| 6. Open bottom structures | 15.0% | medium | NA | medium | No | Structure must encompass bankfull width. This type of structure may not be appropriate on fine grained alluvium (silt and |
| 7. Ford | any stream grade | low-high depending on stream gradient | NA | low | No | Fords typically do not allow year round or heavy traffic. On stream gradients > 2% special designs are required. Use of crossing may be limited by flow conditions and timing of fish spawn. |
| 8. Bridges | any stream grade | medium | NA | low | No | Although this alternative is the most expensive, it is usually considered the best for fish passage, has longevity, and minimal maintenance requirements. |

** The allowable slope varies with the type of corrugation, the length of pipe and the timing of fish migration.

Table 2: Information on various **temporary** stream crossing alternatives.

| Stream Crossing Alternatives | Maximum stream gradient allowing for fish passage | Technical Difficulty (low/med/high) | Seasonal Timing Issue | Potential of Plugging (low/med/high) | Additional Comments |
|---|---|-------------------------------------|-----------------------|--------------------------------------|---|
| 1. Glulam Mat | any stream grade | low | Yes | medium | Utilize on crossings for minimal disturbance. Ends of Mat should bear on even level ground at least 5 feet wide. Place mats next to one another to achieve desired crossing width. |
| 2. Steel Bridge (Pass Through Design) | any stream grade | medium | No | low | Typical pass through bridge design geometry, with bridge structure removed when not needed. Footings may be left in place or removed depending on next use. Rip rap of approaches may or may not be needed. |
| 3. Log Crossing | 15.0% | low | Yes | high | Cut to length log crossing utilizing at least one 18 to 24 inch diameter culvert, cables placed on bare ground for less disturbance at removal. Geotextile fabric used at bottom and top of logs. Highly restrictive time of use based on fish species present. |
| 4. Culverts Designed for Fish Passage | see Table 1 | low to high | No | medium | Smooth or concrete culverts require flatter slopes than those listed. Round culverts maintain the deepest depths during low flow. If depths < 3" occur during low flow consider another alternative. |
| 5. Culverts Not Designed for Fish Passage | any stream grade | low | Yes | medium to high | Temporary culvert installation should be sized for 50 year event. Highly restrictive time of use based on fish species present. Must have good fish species information to utilize this option. |
| 6. Removal of Existing Stream Crossing | any stream grade | low to medium | Yes | none | Remove existing stream crossing structure at end of timber sale. Lay back or remove fill approaches, and construct sediment mitigation structures; possibly barricade road. May be an opportunity to construct a ford crossing. |

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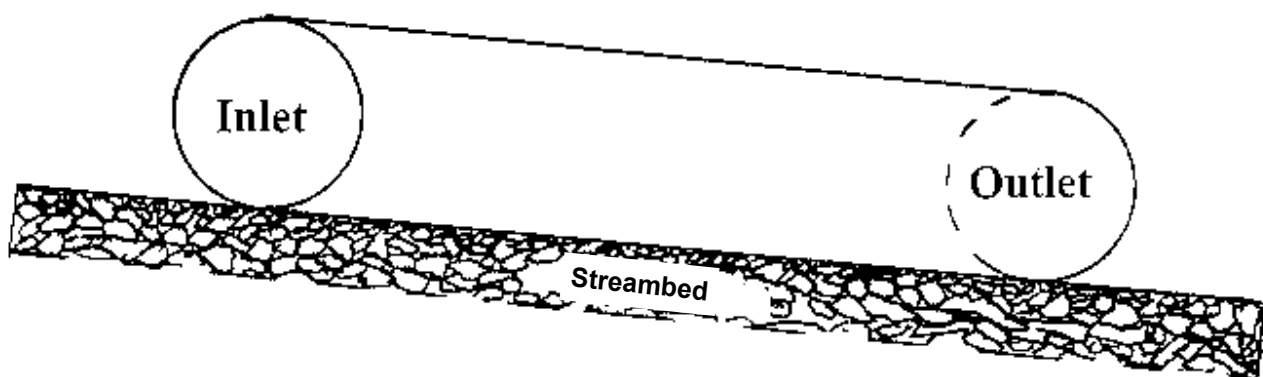
Choosing an Appropriate Stream Crossing Structure

When choosing an appropriate stream crossing structure, landowners and operators must consider long range planning objectives, timber harvest methods, cost, stream gradient, seasonal use, and ease of installation and maintenance. Tables 1 – 3 and Figure 2 discuss and depict the different stream crossing alternatives and can be used as a guide when planning and installing a stream crossing that meets Idaho's requirements for fish passage. When deciding which alternative to use, consider the following steps:

1. Determine if a permanent or temporary crossing is the best choice given long-term transportation requirements or seasonal use.
2. Determine the slope of the stream channel at the proposed crossing site using survey equipment, clinometers and hand levels can not provide the level of accuracy necessary to design and install culverts.
3. Based on the stream's slope and transportation needs, use Chart 1, Tables 1-3, and Figure 2 to determine which types of stream crossings will allow fish passage.
4. Taking into account site conditions, cost, ease of installment and maintenance, choose the most appropriate stream crossing.
5. Tables 1-3 and Figure 2 provide general guidelines for installation. If unfamiliar with installation procedures for the chosen structure, consult a hydrologist or fish biologist.

FIGURE 2. Details for installing various stream crossing alternatives.

- A. Traditional non-embedded culvert at stream grade.
- A culvert should be selected that best fits the stream channel.
 - The resultant culvert grade should be the same as the original stream grade.

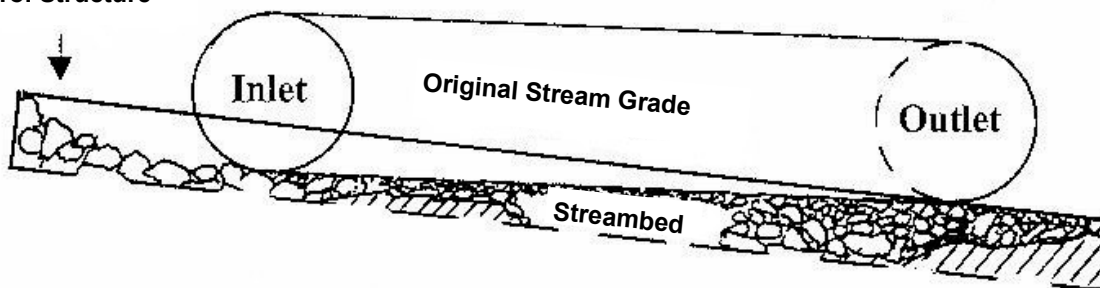


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B. Culvert with Inlet Below Native Stream Grade (Culvert grade is less than stream grade)

- The culvert should attempt to match bankfull width.
- The culvert's inlet should not be buried over 2 ft. or $\frac{1}{2}$ the diameter, whichever is less.
- There can not be more than a 2% difference in slope between the original channel and that of the culvert.
- The streambed should be armored just above the culverts inlet with angular cobble or boulders to prevent a drop from occurring into the culvert and to help prevent headcutting. Consult an experienced individual (e.g. hydrologist) if the stream substrate is composed of silt or sand.
- The resultant culvert grade should not exceed those specified in Chart 1.

**Armoring or Grade
Control Structure**



C. Culvert with Buried Inlet and Outlet

- The culvert will have to be oversized in order to pass the design flow and encompass bankfull width.
- For pipe-arch culverts, bury both ends at least 20% of the culverts heights (pipe-arches are the preferred type of culvert).
- For round pipes, both ends should be buried for at least a minimum of 30% and no more than 50% of the culvert's height.
- Armoring and/or a grade control structure upstream and downstream of the culvert will minimize erosion and help substrates remain inside the culvert. Drops between grade control structures should not exceed 1.0 foot. It is best to backfill inside the culvert with angular cobbles and boulders, although it will often fill naturally. If the substrate is >50% the culvert should at least be sealed with some coarse material.

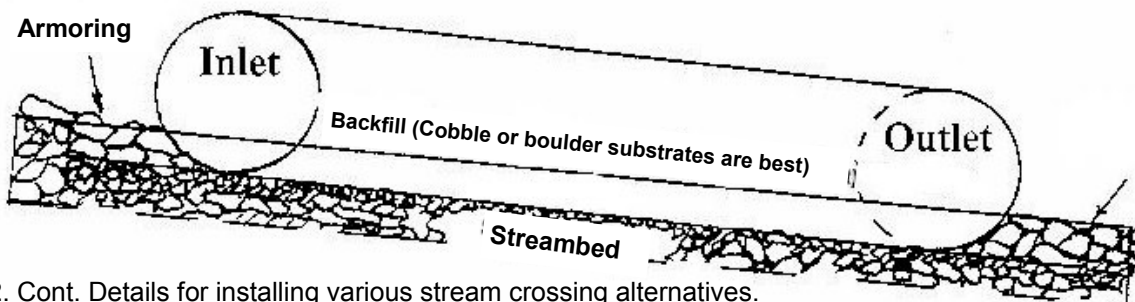
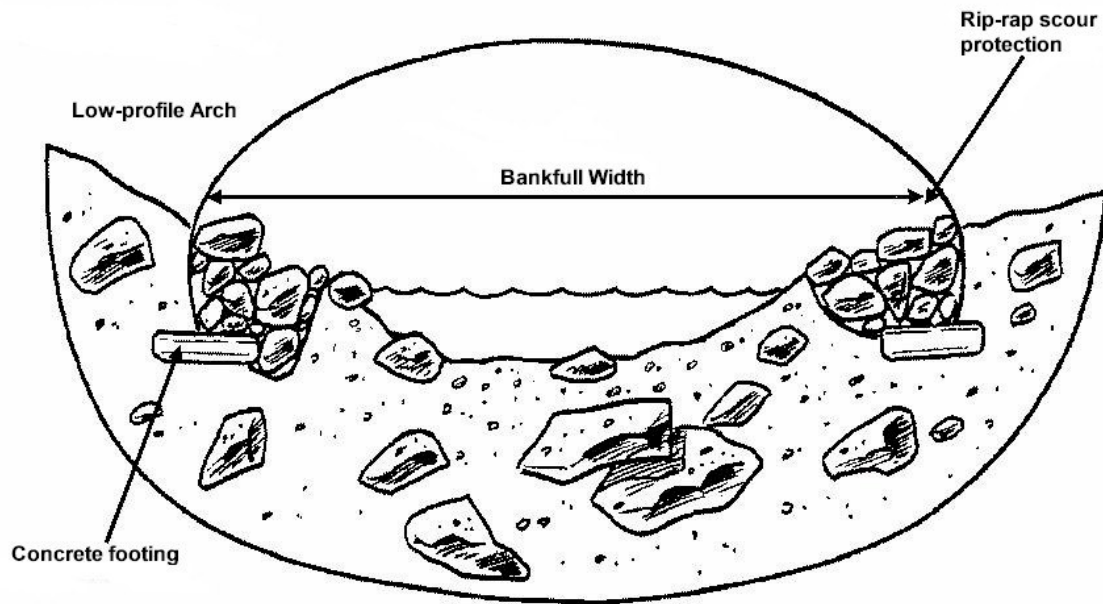


Figure 2. Cont. Details for installing various stream crossing alternatives.

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F. Open Bottom Structures



G. Bridge Design Considerations

Specified debris/navigation
Clearance minimum of 1.0 foot

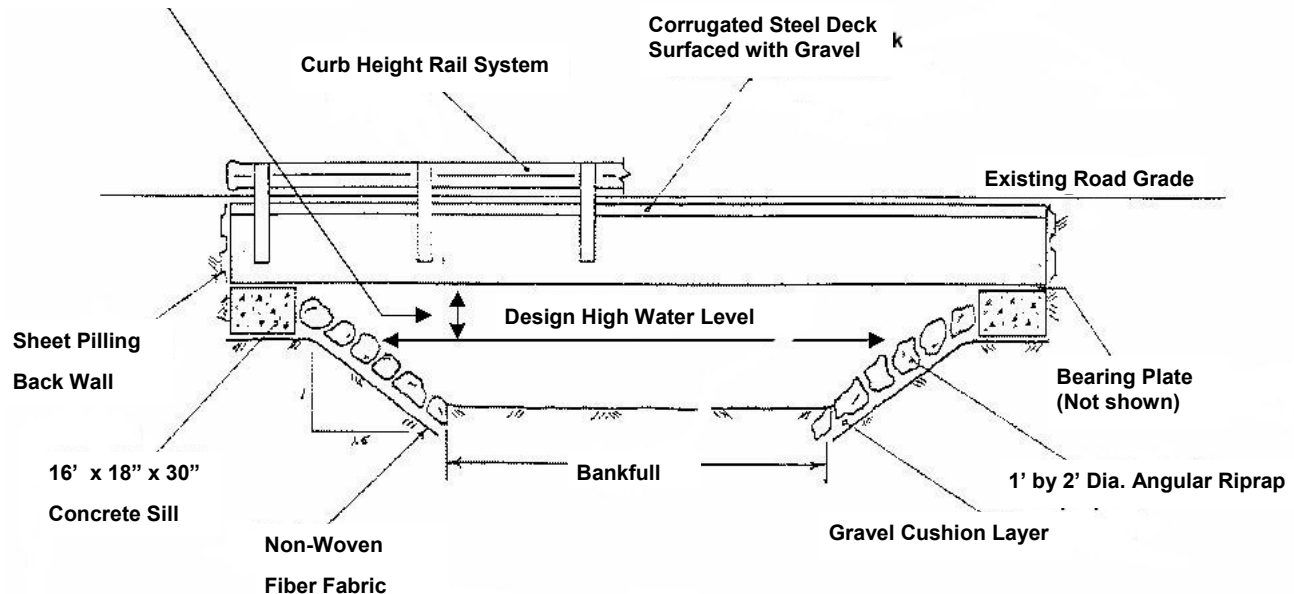


Figure 2. Cont. Details for installing various stream crossing alternatives.

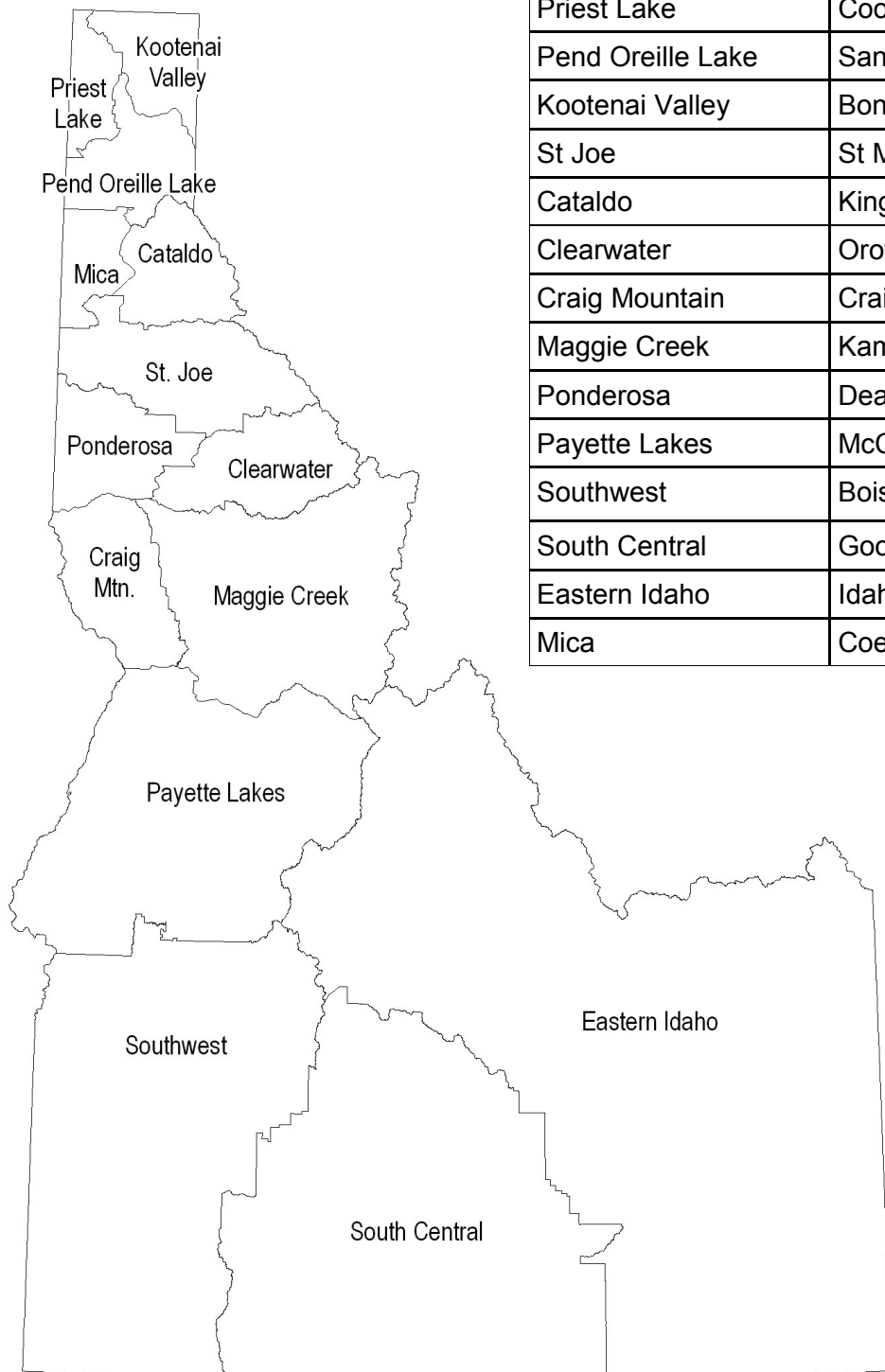
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GLOSSARY

| | |
|--------------------------|---|
| Armoring: | A layer of stone .Armor. placed on the stream bottom to protect erodible material lying underneath. |
| Backfill | Placing earth or a specified size of material in place of material removed during construction, such as in a culvert or trench. |
| Bankfull Width | The bankfull width is marked by a break in slope of the bank and change in vegetation, such as a change from point bar gravel to grasses and forbs. Bankfull discharge flow is sometimes synonymous with ordinary high water flow. |
| Culvert Diameter Class: | Culverts are built in certain sizes, which are classified in diameter classes. Each diameter class increases in six inch increments (18, 24, 30, 36, 42, 48, 54, 60, etc.). |
| Removable Fish Ladder: | Constructed angle iron placed into a culvert to improve fish passage. |
| Grade Control Structure: | A structure placed across a stream channel used to prevent the stream channel from headcutting and used to raise upstream water levels. |
| Headcutting: | The upstream erosion and displacement of stream bottom substrates. The stream channel erosion will often migrate in an upstream fashion. |
| Inlet: | Water flows into the inlet end of the culvert |
| Outlet: | Water flows out of the outlet end of the culvert |
| Resting/Jumping Pool: | A pool downstream of the outlet of a culvert that is deep and flows slowly to allow fish to rest before migrating through the culvert. If a drop occurs from the outlet of the culvert, the resting pool should be deep enough to allow fish to make a run before it jumps. Ideal jumping conditions exist when the ratio of pool to jump height is 1.25:1. |
| Salmonids: | The family of fish including all trout, char, salmon and whitefish. |
| Substrate: | Stream bottom sediments, which may include silt, sand, gravel, cobble, bolder, and bedrock. |



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